A NOVEL VISCOUS INVERSE METHOD : BLENDING A NAVIER-STOKES SOLVER FOR THE ANALYSIS WITH A EULER SOLVER FOR THE DESIGN

Laurent de Vito, France Supervisor: R.A. van den Braembussche

The inverse design has received much attention in theoretical and computational studies and greatly matured. Recently, Leonard [1] and Demeulenaere [2] devised an efficient inverse design method based on a Euler flow solver. Their method allows a pressure distribution to be imposed on the whole blade surface. As their method is still based on the inviscid flow equations, it provides "inviscid" geometries, from which the boundary layer displacement thickness must be subtracted to obtain "metallic" geometries. This subtraction process is critical and may compromise the precision of the whole design procedure. Therefore the next step is to construct a viscous inverse design.

A novel iterative viscous inverse design method has been defined, implemented and validated. The analysis or computations over an impermeable blade is performed using a Navier-Stokes solver. The inverse design or computations over a permeable blade that yields the information of how to evolve the blade profile from one time-step to another is based on a Euler solver and recycles the ingredients of Demeulenaere's inviscid inverse design method that has proven to be fast and robust.

The re-design of the turbine nozzle blade LS89 starting from different arbitrary profiles at subsonic and transonic flow regimes has demonstrated the merits of this approach : the method produces candidates (blade profiles) that meet the objectives, that is, the target pressure distribution, although the original (target) profile can never be fully recovered, which should be ascribed to a loose control of the back pressure to keep the mass flow constant. Moreover, the candidates are oscillation-free, see figure below (the target pressure is that of the original LS89 at $M_{2,is} = 0.97$).

[1] Leonard, O.

Conception et Developpement d'une Methode Inverse de Type

Euler et Application a la Generation de Grilles d'Aubes Transsoniques, PhD Thesis, von Karman Institute and Faculte Polytechnique de Mons, 1992.

[2] Demeulenaere, A.

Conception et Developpement d'une Methode Inverse pour la Generation d' Aubes de Turbomachines, PhD Thesis, von Karman Institute and Universite de Liege, 1997.



